THE THEORY AND PRACTICE

OF

SANITATION IN COUNTRY PLACES

Including the

BACTERIOLYTIC TANK SYSTEM

BY

W. RAMSAY SMITH, M.D., D.Sc., F.R.S. (Edin.),

Permanent Head of the Department of Public Health of South Australia; Fellow of the Royal Institute of Public Health of Great Britain; Chairman of the Board of Examiners for South Australia of the Royal Sanitary Institute; Fellow of the Royal Society of Arts, London; Lieutenant-Colonel, Royal Army Medical Corps (Temp.); Member of the Association of Military Surgeons of the United States; formerly Examiner to the Royal College of Physicians, Edinburgh, &c.

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THE THEORY AND PRACTICE OF SANITATION IN COUNTRY PLACES,

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THE BACTERIOLYTIC TANK SYSTEM.

Everyone is familiar with the changes produced in the dry arid land by a week of soaking rain and genial warmth. What was formerly a desert of bare barren sand is now a field of living green. Trees, dreary and leafless since last autumn, have burst their buds and donned their leafy mantles. The whole earth is covered with varied forms of beauty and wondrous varieties of color, and is redolent with sweet odors. By-and-by field and vineyard and garden will be full of rich fruits, and the forests will be heavier with timber.

But these visible changes are not the only results of plant growth. There are others less obvious but not less wonderful. The living substance contained in innumerable plant cells has been employed in converting certain constituents of the soil into hundreds of "principles" which, though apparently of no direct use to the plants themselves, are nevertheless of unspeakable benefit to mankind. When one considers that from cinchona bark over 60 distinct substances have been separated, and from opium about 40, many of which are of great chemical complexity, one realises something of the enormous extent and variety of the processes going on in the plant and depending upon the relations between the soil and plant life.

Apart from fresh waters and the sea—and man shall no more live by fish alone than by bread—we depend upon the soil, directly or indirectly, for all our food and clothing, our sustenance and our comfort. The necessaries, the luxuries, and the adornments of existence are found in the country. All theories of the origin of the race place the first of mankind in rural surroundings. "God *Almightie,*" says Bacon, "first Planted a Garden. And indeed, it is the purest of Humane pleasures. It is the Greatest Refreshment to the Spirits of Man; Without which, *Buildings* and *Pallaces* are but Grosse Handy-works."

> "God made the country, and man made the town:
> What wonder, then, that health and virtue, gifts
> That can alone make sweet the bitter draught
> That life holds out to all, should most abound
> And least be threatened in the fields and groves?"

We are not now concerned with the mental or moral advantages that a garden or a country life confers; our subject is the more restricted one of health alone. The only light that will illumine it will be the dry light of Science.

"God the first Garden made, and the first City, Cain." Cain is the patron saint, or patron sinner, of all such as build cities. They have no thought for their neighbor. They are not their brother's keeper. Towns are after-thoughts—the requirements of an artificial civilisation. The huddling together of human beings within a city was doubtless due at first to the necessities of defence. When man discovered that he could enlist gravitation in the propulsion of his missiles, he built forts and cities on the hill-tops or hill-sides. Later on, towns arose at the seat of mines because of the advantages connected with manufacture, and around seaports for the convenience of commerce. Social life and health have never received so much consideration as defence and commerce. Towns always had their drawbacks and disadvantages. Architects and health authorities have ever been concerned about open spaces and vegetation between houses, about fresh air and sunlight in and around dwellings, about food and water, and the removal of refuse. Dwellers in cities have often to pay dearly for their so-called privileges, not only in the tale of lives they furnish to epidemics of preventable diseases, but in the shortening of the average human life and in the general low standard of health that characterises them.

It is notorious how city customs and fashions have influenced social life in the country. The same is true of the adjuncts of social life. What in the town is a necessary evil is not only tolerated in the country, but is looked upon as "the correct thing." In the country one cannot unbend one's self from the town twist. A builder finds it impossible to cast away his town-bred ideas, and so he builds underground kitchens and coal cellars in his country mansion, being so long accustomed to build houses on a minimum of superficial area that, when he has unlimited space at his disposal, he fails to appreciate the advantages of the boon. It is doubtful if the invention of the telephone and the electric car, which ought to obviate the necessity of the crowding together of men for commercial purposes, will be able to break down habits that have become part of our being. Customs unfortunately persist after their necessity or utility has ceased.

On this subject Professor Alfred Kirchhoff wrote:—"It is not true to say that the progress of civilisation liberates man from the influence of mother earth: on the contrary, it is always knitting him with it more and more intimately and comprehensively. We feel ourselves ever more and more at home upon the earth, more and more fortunate in being able to turn to account its gifts and its forces, and yet it remains the fundamental basis of human activity."

Unfortunately we rarely recognise that this is so. The circumstances of our life and living and the conditions of our work and amusements have become so artificial, so unnatural, so complicated and interdependent, so out of touch with nature, that when we find that anything has gone wrong we have great difficulty in finding where or in what the real fault lies. For example, it is only within the present decade that we have learned something of the meaning of the term "fresh air" in matters relating to our living and working. Careful observations and experiments have completely changed our ideas about ventilation and the characters of foul air. It has now been found that what really counts is not so much the air we breathe as the air in which our skin is living. The recognition of this has made a vast difference in hygiene and economics alike. Its influence has extended from battleships to lace stockings.

We have come to see that it is our by-products that first inhibit our energy and then extinguish our bodily life. Just as fermentation comes to a point where the organism is killed by the increase of its waste products of growth, *e.g.*, in alcoholic fermentation of wines, so also if human beings were as limited in their means of expansion and as unable to get rid of their waste products the race would become extinct. As it is, our unnatural modes of living give rise to bad health, malnutrition, stunted development, a high death rate, and the propagation of the less fit, to the great detriment of the race and national welfare.

The intimate connection between bodily conditions and mental states has been noted in time past by some thinkers. James Hinton, surgeon and moralist, wrote in 1866 in a philosophical discussion what has now been proved to be more than a mere analogy on the subject of the treatment of the by-products of life. He said:—"How is the hurtful thing to be rendered harmless, the mischief to be neutralised? Our whole knowledge of nature and of life concur in giving one answer: it must be turned to use. Things cease to hurt us then, and then only permanently, when they are made to serve our good. Nor can it be otherwise, for nothing can be annihilated, nothing hindered from having, in some form or other, its full effect. The mere putting away or putting down evils has never succeeded. They return with a violence increased by the delay. The one condition upon which we can really avoid suffering by hurtful things is, that we should use them and make them serve us. A striking instance—though it is but an instance of a universal law—is given by the problem with which every large body of persons has to strive, of disposing of the waste materials of their life. Hurtful to a high degree, these waste materials are the source of inevitable disease if they are not put utterly away. But how thus utterly put them away? There is but one method that is truly efficient, and that is, to make them subservient to the increase of the means of life, to render them the fertilisers of our lands, the source of food. The drainage of towns will either poison or be an enormous tax, or it will feed. The condition of its ceasing to be an evil is, that it shall become a good. Necessarily it is so: its effects cannot be made null; our only choice is, shall they work our mischief or our benefit?''

Perhaps man's most profitable study nowadays is how to enlist the whole of the energies of matter and mind as his helpers in life and action, instead of having some of them as constant wastages, embarrassments, and hindrances—in figurative language, how to economise time and energy by utilising the recoil of the gun to bring the piece back automatically to its former position or condition, ready to fire the next round.

The problems of health in cities are complex and difficult. All systems of city sanitation are expensive and unsatisfactory. Scientific hygiene, *i.e.*, sanitation by the employment of the ordinary processes of nature, can be carried out only in the country, or in places where each house has its garden or small plot of land surrounding or adjoining it. Dr. Poore, a writer to whom reference will again be made, says—''Sanitation is purely an agricultural question, and in the country, where every cottage has, or should have, its patch of garden, there ought to be no difficulty in the daily removal of refuse from the house, and in applying it to agricultural purposes, without any risk of contaminating the water supply. Given the patch of garden, the only thing necessary to bring about this, the only complete form of sanitation, is the will to do it—the will, that is, to do a profit to one's self, without the possibility of damaging one's neighbor. This, unfortunately, is rarely forthcoming, in spite of the Christian religion and the Education Act, and we go on, even in country places, polluting our streams and wells, with our minds agitated, as well they may be, as to when our water will become too poisonous to drink, and where we shall turn for a pure supply in the future. Sanitation is a purely agricultural and biological question. It is not an engineering question, and it is not a chemical question, and the more of engineering and chemistry we apply to sanitation the more difficult is the purifying agriculture. This, at least, has been the practical result in this country.''

Over 30 years ago a Commission reported to the Municipal Authority of Turin that chemical methods of treating sewage had proved ineffective, costly and dangerous unless followed up by some method of oxidation; and that the only method of sewage purification to date that had proved efficacious was irrigation in a proper way on suitable soil. About the same time it appears that irrigation was looked upon in Germany as being satisfactory and non-offensive.

Dr. Poore spoke of England. Shall we find the conditions different in other countries? Let us inquire into the facts and factors of natural or biological sanitation—that is, purification by means of plants and animals, as distinguished from chemical purification—and try to answer the question.

Reference has been made to the growth of plants. As a rule plants by their roots take up water with certain substances in solution in it. This sap, passing to the leaves, comes into contact with the oxygen of carbon dioxide that has been taken in by the leaves. The result, under the influence of sunlight, is the formation of starch. This in turn is converted into a soluble substance from which the wood, bast, cork, and all the tissues composing the plant are derived. The total effect of these processes on the earth and air is (1) to increase the amount of oxygen and decrease the amount of carbon dioxide in the air; (2) to lessen the amount of animal and mineral substances in the soil. The first process is called purifying the atmosphere, because it restores the balance of oxygen which has been disturbed by the breathing of animals; the second process is spoken of as a purifying of the soil, because the emanations from decaying animal material would prove harmful to living animals if the products of decomposition were not utilised by plants. When we speak of purification it will be noted that we speak from the point of view of the requirements of animals, not of plants.

The obvious or evident plant-growth, however, is, as has been said, only a small part of the processes that go on; and the plants we see form but a small part of the whole as regards number and variety. Every cubic inch of mould teems with myriads of minute plants known as germs, microbes, micro-organisms, or bacteria. These are concerned in the processes of breaking up organic matter—that is, material derived from plants and animals—and making it available as food for the green plants referred to. Besides these there are other microbes, not long known, that are employed in making the free nitrogen in the soil available as the direct food for certain kinds of plants. It has been found that the roots of some kinds of plants—especially leguminous plants like peas, clover, and vetches—have swellings on them which are found to be made up of tissues containing numerous bacteria. The process of planting these collections of bacteria in soil in which they are not naturally present is known as "inoculating the soil." Finally, there are plants known as saprophytes, on account of their feeding directly upon decaying organic matter. As examples of these we may mention fungi.

Thus the soil, as the abode of all these plants, is fitted to deal with all sorts of organic refuse. Plants die. Animal eats plant or other animal; the refuse, dung, or undigested food, is composed of animal and vegetable matter. The animal itself dies, falls on the soil and is decomposed. Thus garbage, the dung of animals, animals themselves, and human excreta are all transformed by decomposition, a process which is essentially a fermentation; and the products of this decomposition in the soil are utilised by plants for their life and growth. We have seen that the process of transformation into plant substance provides us with food and purifies the atmosphere.

This, however, is not all. This same soil protects our water supplies. For it has been found that only mould, or the superficial soil, possesses the transforming power referred to. The subsoil, which contains little if any of the sort of germ life mentioned, is ineffective as a biological purifier, though, by retaining particles of refuse, it acts to a certain extent as a mechanical filter. The result is that if organic matter is buried deeply, by which we mean below the mould or surface soil, it may remain unchanged for months or even years. Privy pits dug deep in the subsoil have been covered up, and after many years they have been reopened, and their contents have been found fresh looking, as offensive, and as dangerous as when they were buried. The same thing is true of dead bodies. Hamlet asked, "How long will a man lie i' the earth ere he rot?" ; and the gravedigger said, "He will last you some eight year or nine year." This obviously refers to the long-established practice of deep burial. A body buried in mould 3ft. deep or thereby will in 12 months' time show nothing but bones. On the other hand, one buried deeply in the subsoil may remain in such a fresh condition as to give origin, many years later, to tales of miraculous preservation against corruption. When organic matter is buried deeply it may, instead of remaining unchanged where it was buried, be carried by water—either mechanically or in solution—to great distances, even miles, underground, and may thus contaminate wells in the neighborhood or at a distance. Herein is found the explanation of how cesspools become dangerous to a community. Their contents soak into the surrounding subsoil.

To the mechanical and biological actions of the superficial soil or mould as a filter we must look for the protection of our water supplies. So long as dead animal and vegetable matter decomposes on or in the mould, so long will the decomposition be complete and the resulting products harmless. There need be no fear of applying too much dung to the mould or of exhausting its powers. The more it is given to do the more it does, and the more it becomes capable of doing, so long as it is "cropped."

Animal matter and other nitrogenous material in contact with the soil undergoes decomposition without offending our sense of smell or injuring our health. Such decomposition, we have seen, is effected by the visible and invisible plants of the mould. The conditions under which this takes place are as follows:—(1) A certain amount of air in the soil is necessary, *i.e.,* the soil should be porous, and not waterlogged—portions of a field that have been waterlogged show as bare patches in the midst of an abundant crop; (2) a certain amount of moisture is essential, preferably about 33 per cent.; (3) the active processes are best carried on at a temperature of 50°-55° C. (122°-131° F.). It will be seen that the conditions in this country are much more favorable to complete and speedy decomposition than they are in England.

Certain details require to be noted. No disinfectants should be used; they sterilise the soil by killing the active microbes. Perfect decomposition is shown by the absence of offensiveness. Smell, whether from large fermenting heaps of manure or small quantities of excreta or urine, means waste of useful material. It does not necessarily mean danger. The ammonia from a dung heap is the same substance that we buy in bottles for domestic purposes. On the other hand, absence of smell does not necessarily imply safety. Some conditions that are extremely dangerous to health are associated with no offensiveness.

As has been said, the power of the soil to decompose manure, excreta, and garbage increases by use. One cannot state a limit, but it has been found that it is possible to put as much as 200 tons of stable manure per annum on an acre of market garden land near London—the average being from 60 tons to 80 tons. The soil in this country could take that quantity and even more. All this is utilised by the crops grown on the land.

As regards excreta, it has no doubt often been observed that when these are deposited on or in the mould, decomposition takes place rapidly and without offensiveness. One has only to study the sanitary methods and results of that most cleanly of domestic animals, the cat, in order to be convinced of this. Other conditions being similar, it makes no difference whether the excreta are taken to the earth, or the earth taken to the excreta. The immediate treatment can be begun in an earth closet.

THE DRY EARTH CLOSET SYSTEM.

In 1874 the State Board of Health of Massachusetts published a report on the subject of the health of farmers and farmers' families in that State. It was the outcome of a series of very extensive investigations made by country doctors in response to questions asked by the Board. The following quotation from the report refers to a state of affairs that is, unfortunately, not confined to Massachusetts:—"As to country privies, one of our correspondents has well said that they are 'a disgrace to civilisation.' The common country privy, unventilated, except by the door, standing over a reeking mass of corruption, either contained in a vault or lying upon the surface of the ground, a place foul and pestilential beyond description,—this must be the daily resort of every member of the farmer's family. If it adjoins the house, its poisonous odors penetrate to the living rooms; if standing several rods away, as it frequently does, an exposure to the weather is involved in reaching it. In either case, in winter it is frightfully cold, and its use involves a chill, which, to women and children especially, coming from the warm rooms, is a potent cause of disease. Undoubtedly, the constipation which is so general among country women is, in great part, due to the dread of going to this abominable place."

Something requires to be said about school closets. The Parliament of the Commonwealth of Pennsylvania in 1893 passed an Act "For the better protection of the health and morals of school children." This law requires the board of directors of the school to provide suitable and convenient closets, separate for boys and girls, and unless placed at a remote distance from each other the approaches shall be separated by a close fence not less than 7ft. high; and it imposes on the directors the duty of keeping the closets clean, comfortable, and healthful. Neglect of these duties makes the directors liable to be removed from their office by the Court of Quarter Sessions. The State Board of Health calls attention to this Act in a circular to school directors, and in that communication says some very plain things regarding school privies. "A shameless disregard of the proprieties of life and the allowance of the vilest accumulations of filth, coupled with inconvenience and rudeness of accommodations, characterise the conveniences provided by too many school boards. It must not be supposed that in the opinion of this Board school directors and controllers are in any considerable degree more negligent than their constituents in this matter. The condition of the sanitary, or unsanitary, more strictly, arrangements for the school is simply too often a reproduction of those which exist at the home."

The Board says the privies should be absolutely distinct for each sex—"out of sight and out of mind" each from the other; and they recommend the adoption of the earth closet in preference to the dangerous privy vault. The Board also calls special attention of the school boards to the fact that they cannot draw their annual grants from the State until the President of the School Board has certified that the requirements of the Act for the thorough disinfection and cleaning of the outhouses have been duly complied with.

The condition of affairs in the State of New York is thus referred to by a well-known sanitarian and former member of the New York Board of Health:—"In addition to the well-known dangers attending the neglected accumulations in privy-vaults, few things are more destructive to health and comfort than dependence on one of these dreadful outbuildings. A visit to one of them involves an amount of exposure in cold weather which even strong men have reason to dread. In the case of women, children, and invalids, what can be worse than a plunge out of doors in cold or stormy weather, usually without the precaution of extra clothing or overshoes, for a visit to the foul shrine of cloacina? The neglect of regular attention to the calls of nature, which the dread of this exposure induces, tends to encourage women and children in disregarding them as long as possible, until the evils inevitably attendant upon the habit of constipation, much too prevalent in this country, are induced and confirmed. The head of a family who makes no better provision for the needs of his household, neglects the most obvious of his sanitary duties."

These words have acquired a new meaning and an added force from the scientific interest that has been awakened in the interval since they were written. The whole psychology of work and well-being is becoming established on a basis of careful observation and scientific experiment; and the interdependence of body and mind is being recognised as of the utmost account in life and well-being. Robert Louis Stevenson said:—"To wash in one of God's rivers in the open air seems to me a sort of cheerful solemnity or semi-pagan act of worship. To dabble among dishes in a bedroom may perhaps make clean the body, but the imagination takes no share in such a cleansing."

Indecency, humiliation, degradation, wrong doing, are usually associated with secrecy; and by some "conversion of propositions," or by the repeated conscious or unconscious association of ideas and feelings, people had come to imagine that all actions of a private and personal character must necessarily be inherently indecent, humiliating, degrading, or morally wrong. This is a remnant of the times when mistaken teaching compelled or encouraged people to regard natural acts as necessary but sinful, and not those acts alone that ministered to the well-being of the individual, but also those that were essential to the life of the race. A saner science and a better biology have taught us that all actions necessary for the requirements of good health are naturally associated in the individual with feelings of active cleanliness, goodness, and joy. This truth should be inculcated in the young from birth. True cleanliness consists in being clean, looking clean, and feeling clean.

In some matters we can point to progress. Our bath establishments are no longer hidden in out of the way or dark places. Our closets are improving as regards position and structure. They are becoming more open, more simply yet more tastefully fitted, more pleasing in external appearance and less "distinctive" in their architecture. The standard of civilization in a community is evidenced by its public sanitary conveniences. Family refinement is gauged by the back yards, not by the front lawns.

The closet may be at some distance from the house, with which it may be connected by a trellised way covered with creepers. The path to it should be so constructed as to ensure its being dry in all seasons and at all times. In general structure it may resemble a water-closet. If not concealed, its features should be such as bring it into something approaching harmony with the ordinary architectural features of our houses and their surroundings. Figure 1 shows a shelter shed with lavatories and closets connected with a bacteriolytic tank, for children attending a Montessori Garden House of Childhood. Figure 2 shows a typical old-time privy at a great distance from the dwelling-house of a farmer. It was built partly over a creek, into which it discharged directly. It was condemned and removed by order. These two figures show a marked contrast, and might illustrate the commendable and condemnable in sanitary appliances.

The closet requisites are a pail under the seat, a box to hold the earth, and a small scoop to spread the earth over the excreta. The seat should not be more than 14in. high; the opening should be oval.† It has been found that constipation and other evils are induced or aggravated by high closet seats. It is unnatural that the feet should be off the ground, and the squatting position, with the body bent slightly forward, has been found to be the most hygienic. In some countries, such as France, ordinary closets have no seats or pedestals. There, as in the East, the closet, *à la Turque,* is common.

The Pail should be light and manageable, and so shaped as to be easily kept clean. A convenient form used here (*see* Fig. 3) is a cylindrical pail of galvanised or enamelled iron, 13in. in diameter and 12in. high, with a handle attached at some distance below the rim to allow a lid to be used, if desired, when carrying it away. The pail should fit as closely as possible under the seat, between guiding runners or by some other contrivance.

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† Dr. Groff, of the Pennsylvania State Board of Health, says:—"The hole in the seat should be long from front to back, but narrow from side to side, never made circular, with a pair of dividers, as a country carpenter will invariably make it unless otherwise instructed. The proper dimensions are 11in. x 4in. The edges should be moderately bevelled. This shape will make the act of relief much easier, and tend greatly to prevent that painful disease, hæmorrhoids."

The simplest arrangement in the closet is to have a movable seat, which can be placed directly on top of the pail. This allows of seats with various sizes of apertures to be used if so desired. The next simplest method is to place the pail in a corner, and to have a seat so hinged to one side of the closet that it rests, when level, on a bracket on the adjacent side. This obviates the necessity of a "box"—a structure that is objectionable for several reasons. It also does away with the necessity of having an opening at the back of the closet through which to remove the pail. Should the seat be considered too low for infirm people, handles may be attached to the walls to assist in rising up.

Toilet paper should be used. In the first place it costs something, and this is a check on using an unnecessarily large quantity, which is an untidy and objectionable custom; secondly, it is preferable on the grounds of health, since printing ink has been found to be harmful by causing or aggravating local unhealthy bodily conditions.

It should be part of every child's education at home and at school to use the closet in the proper way, and to keep it scrupulously clean. If people only spent one-tenth of the time attending to the excretory functions that they do to procuring and preparing their food they would be very much healthier.

The Earth for use in the closet should consist of dry garden mould, dry clay, brick earth, road dust, or soil in which grass or other vegetable life has existed. Sand and gravel are bad; chalk is not good. Wood ashes and coal ashes—not cinders—may be used. The amount of earth required is surprisingly small. Half a ton a year has been found ample for a family of seven or eight persons. The earth is sifted and stored under cover in quantity. Every time the closet is used a thin layer of earth is scattered over the excreta. The agricultural value of the product is lessened if much earth is used. The pail may be attended to daily or less frequently. If there is a garden belonging to the house, the contents may be buried in a shallow trench and covered in at once. If not, they may be put in some place under cover, turned over once or twice, and used again after a few weeks, even several times in succession. On the other hand, the sanitary authority of the district may collect the contents and take them to a piece of ground to be dealt with as a private individual would deal with them.

Under the Health Act of 1898, section 78, a local board of health in this State has power to undertake or contract for the removal of nightsoil, and can make regulations requiring the occupiers of premises to provide receptacles in convenient places, and forbidding anyone to deposit refuse or nightsoil in any other than the places they specify. Recent legislation empowers a local board to rate part of its district, say a seaside resort in a large country area, and to expend the money so raised in carrying out the sanitary administration of such a part. It may be said—in fact it is often said—that some people will not take the trouble to use the earth closet as it ought to be used. That is quite true. Some people will not take the trouble to pull the chain of the water-closet cistern. That, however, is no reason why they should be allowed to have their closet in an offensive condition; and any person who permits such a place to become offensive—and offensiveness means neglect—is liable to a penalty of £20 under section 76 of the same Act.

If it should be found inconvenient to empty the pails of the earth closet as frequently as has been recommended, then a "dry catch" may be employed (see Fig. 4). In this the pail is dispensed with; the floor of the closet, which should be of smooth concrete, is made to slope slightly towards the ground outside; a trench is made to carry away or retain urine, and the contents need not be removed for weeks or even months. When removed they are treated in the same manner as in the earth closet system.

The burying of the contents of the pails or the "catch" should be done systematically in "garden ground." A trench is dug the width of an ordinary spade blade, and as deep as the blade is long. In this the contents of the pail are placed and are completely covered at once with earth so dug as to form a parallel trench at the distance of a spade's width from the first. The ground where the excreta have been buried should be planted with cabbages, onions, lettuce, spinach, or other such vegetables. The amount of land required for this sort of sanitation is not great; half an acre would be sufficient for a thousand people for a year.

Any ordinary form of cart is sufficient for the removal of the contents of the closet pans, and there is no objection to such removal being effected during the day.

It must be noted that this dry earth system of treating excreta is very different from a pail system in which no earth is used. In such a system—commonly known as the sealed pan or double pan system—the excreta very soon become offensive from decomposition, and cannot be utilised at once in the same fashion as when mixed immediately with dry earth. The nightsoil is generally buried deeply at a considerable distance from the township. The system is cumbersome, offensive, and wasteful; but in certain circumstances it is, unfortunately, the only system applicable. There is not, however, in this State any city or township or country place in which it need be adopted. There exist everywhere throughout our State conditions that make the employment of the dry earth closet system quite practicable.

The earth closet costs less at first than the privy pit. The material removed can all be utilised without offensiveness, and at a profit to the farmer or gardener; hence there can be no excuse for not adopting the closet system. If it be said that it costs a great deal to fill up a privy pit and buy a pail, the reply is that it costs a great deal more not to do it. This is what Dr. Billings, a well-known American writer, says about a system of sanitation that is too common:—"The cesspool is still the chief reliance of the world at large. There is nothing to be said in its favor save what may be based on the old adage that 'what is out of sight is out of mind.' There is everything to be said in its condemnation, whether we regard its contents as a great mass of putrefying and infecting filth, as the source of oozings which travel through crevices of rocks, through layers of gravel, through seams in clay, or through lighter soils into and under cellars and into drinking water wells and defectively-constructed cisterns, or as an ever-active gas-retort supplying the pipes of the house with the foulest products of putrefaction. It is in all respects and under all circumstances a curse, unless placed far away from the possibility of tainting the air we breathe or the soil over which we live, or from which we or others take our drinking water, and even then it had better be abandoned."

Urine.—The treatment of this requires some notice. In the earth closet urine may be separated from the excreta by a simple arrangement. In ordinary circumstances the quantity passed into the pail does not interfere with the proper treatment of the excreta. For larger quantities of urine, however, it is well to make separate provision. A "dry urinal" may be made of a receptacle containing sawdust or "chaff." The sawdust or chaff should be stirred up once a day. When this begins to be offensive, which may be in some months, it is ready to be used as manure. In this respect it differs from fresh sawdust, which makes bad manure. The urine in such urinals should never be diluted with water; and it should be remembered that a mixture of urine and soapy water, when allowed to stagnate, stinks vilely. Further, pure urine is too strong to be used continuously on a small piece of ground.

Kitchen and Pantry Slops.—These consist of water containing grease and suspended matter, bits of food, tea leaves, and such like materials. The method adopted by Dr. Poore, following recommendations by the Rev. Henry Moule, about 1866, for dealing with these slops, is as follows:—From the sink (which should not be made of lead, but of enamelled iron or earthenware) a pipe passes through and projects beyond the wall of the house to a distance of about 18in., and at a height of 30in. above the ground. The slops run into a basket containing paper or a wisp of hay or grass, which acts as a rough but efficient strainer for fatty matter. Under this basket is a filter in duplicate, consisting of a box filled with broken clinker or gravel varying from the size of peas at the bottom to walnuts at the top. The outlet leads to a perforated iron gutter, which is flush with the surface of the ground and is supported at intervals by bricks in a trench filled with loose rubble, clinker, or such like material. The bottom of this trench slopes so that the slops may not flow towards the house. The surface of the gutter has a very slight fall. The perforations increase in diameter from the upper to the lower surface. Twelve feet of guttering should prove ample. The flow from the basket is so arranged that after one compartment of the box has been utilised as a filter for a few weeks the slops are directed into the other. The only attention the system requires is the renewal of the paper in the basket about once a fortnight, and keeping the gutter clear of leaves and other materials that would choke it. The filter-box may be considered a luxury; if so, it may be replaced by an old pail with a hole in the bottom. Details of the scheme may be gathered from the drawing in Fig. 5.

Bedroom Slops.—These consist of urine and soapy water from the wash-basin. The water from the bath may also be included. Such slops may be run directly, without any straining or filtering, into a gutter scooped out with a garden hoe and conducted to a few square yards of garden bed or planted ground. The amount of land required for dealing with all slops is very small. It has been estimated at an acre for 7,000 persons, or little more than 6 sq. ft. for each. At Mannum, on the River Murray, great difficulty was experienced in some cases on account of the houses being situated on a narrow strip between the cliffs and the main street, which was parallel to the river. Fig. 6 shows how part of a narrow lane between two houses was tilled and planted with greenery. This little strip proved sufficient for the needs of a household. In other cases a small patch of back or front garden proved ample. We are apt to forget how much greater vegetable transpiration is than mere evaporation of water from the soil.

Water from the bath should always be utilised for the garden or for similar purposes. The domestic waste of this water is very great. In a climate like ours a shower bath, which means a bucketful of water, is preferable to a plunge bath, which takes many gallons. When water is scarce even the shower bath may be dispensed with in favor of a towel-bath, made by dipping a bath towel in a basin of cold water, wringing it out, and rubbing the body all over with it. The action on the system is as good as, and in many cases better than, either the plunge bath or the shower. People waste water very thoughtlessly, and then when a drought comes they ask the clergy to pray for rain. Canon Kingsley answered such thus:—"Ere you ask for more rain, make places wherein you can keep it when you have it." The rebuke of a Bishop of Melbourne was, perhaps, more Australian in character. He is reported to have said:—"What you people want is to pray less and dam more."

Garbage.—Under this term may be included all the refuse of the house and garden, such as remains of food, bones, rags, horn, leather, parings and waste pieces of vegetables, leaves, weeds, mowings of the lawn and sweepings of the walks. Whatever is useful for pig-feeding is placed in the pig bucket, which ought to be covered with a tight lid, in order not to attract flies. Other materials may be placed in a receptacle in the garden or elsewhere formed by a piece of rabbit netting and two or three uprights. Should the heap thus formed and accumulating begin to be offensive, a little earth scattered over it will put an end to the offensiveness. Pieces of glass and crockery, if broken up, form a good foundation for roads and garden paths; so also do coal cinders. "Green bones," either whole or broken down, if not too fatty, form good manure for the garden, and especially for orange trees, and give the trees a healthy, luxuriant appearance and improve the quality of the fruit. On the other hand, dry bones check the growth, and in some places owners have had to dig them up and remove them, with considerable trouble and at a good deal of cost. Bones do best on sandy and clayey soils and grass lands. On humid and calcareous soils they are of little use. Old tins may be utilised as flowerpots, or pounded down for foundations of roads or garden walks, or buried deeply. They should never be allowed to stand about, since they collect water, and thus form the breeding-grounds of numberless mosquitoes. Dry bones and shells of oysters and other shellfish should be burned, and the ashes used for manure. All these materials should be sorted out, and the receptacles of them kept tidy. Yards and gardens may be clean and yet far from clean-looking just on account of untidiness.

The sanitary apparatus required for use in the country is summed up in two words—*fire* and *soil*; the methods are strong burning and light burying.

Much has been written on the results of the dry earth system since it was first brought into prominence by the Rev. Henry Moule. A very extensive report was made to the Privy Council in England, in 1869, by Dr. Buchanan, the Medical Officer, regarding the practical working of the system in isolated cottages, public institutions, and villages. Dr. Corfield has discussed the *pros* and *cons* of the method in his book on "The Treatment and Utilisation of Sewage." The subject is also referred to in nearly all standard works on hygiene, and there is a great deal of literature bearing upon it in reports of health authorities in the United States and elsewhere. Dr. Vivian Poore, an ardent sanitarian, who was Professor of Medicine in University College, London, and for many years honorary secretary to the Parkes Museum of Hygiene, discusses the subject at length in three books*, in which he sets forth his practical experience as a sanitary reformer and property-owner in the country:—He says:—

"I have studied somewhat closely for the past 18 years the result of applying human fæces to a well-tilled humus, and I

* "Essays on Rural Hygiene," 3rd edition, 1903; "The Earth in Relation to the Preservation and Destruction of Contagia," 1902; "The Dwelling House," 1898.

feel convinced that many who write upon the subject have taken but little pains to inform themselves as to the real facts.

"It will not be uninteresting, perhaps, if I give some of the results of my small experiment at Andover, which is now in its fourteenth year of trial. In this experiment the ordure and house refuse of about 100 persons have been removed and applied daily for gardening purposes. The amount now under the spade is exactly 1 acre 1 rood 7 poles, and I should like to say that the quantity of fæcal matter at the disposal of my gardener by no means satisfies him. I am also convinced that the garden might take with advantage at least double the quantity if not more. There is no evidence, after a long experience, that the soil is overdone. On the contrary, its 'condition' has steadily improved.

"In the middle of my garden is a well, which affords evidence that no fæcal matters are washed downwards to the subsoil water. This well, which was made mainly for experimental purposes, is very shallow, little more than a dip-hole. The bottom is 5½ft. from the surface of the ground; the sides are lined with concrete pipes to the very bottom, and around these 4in. of concrete have been run in in order to give additional protection. There is a good parapet and a movable cover. The well was made in 1891, and the bottom and sides look as clean to-day as when they were made. No water can possibly enter this well except through the bottom, and I drink the water without any hesitation or misgiving, because I know there are no leaking sewers or cesspools in the immediate vicinity.

"I have said that this garden of 1¼ acre was manured with the refuse of about 100 persons for some years, and it may be stated that, proceeding methodically, it took four years to go completely over the whole of the ground in cultivation. The observer was usually astonished at the small amount of excremental material which has to be dealt with, not more, usually, than will lie in a furrow 10ft. or 12ft. in length made in the ground with a spade. Directly it is deposited in the furrow it is lightly covered, and there is an end for ever of any offence or any danger. The first crop taken off the land is always a succulent green crop of the cabbage tribe, and the plants are dibbled in on the third day after the deposit. No other crops except cabbages seem to flourish in the fresh material, but the cabbages may be followed by potatoes, these by celery (planted between the rows), the celery by peas or beans, and these again by parsnips or carrots, without any fresh manuring, and with a most abundant yield. There is no doubt that this excremental refuse confers a fertility upon the soil which is not exhausted for years. I have been urged by some practical gardeners not to apply the material to the ground at once, but to store it in a heap with earth and ashes to allow it to 'ripen' before applying it. Those who give this advice have derived their experience from 'nightsoil' from privy pits which has undergone a certain amount of desiccation by the draining away of the fluid matter, and which is undoubtedly a most potent and dangerous manure when applied pure without previous admixture with earth and exposure to the air. By immediate burial before ammoniacal decomposition sets in there is no danger of this kind, and one is sure that nothing is lost. Further, if excrement be left above the ground, blowflies and other insects will deposit eggs in it, and then the gardener will complain that 'closet-earth brings grubs,' but by immediate burial this drawback is avoided. Many practical gardeners who have seen the results of the plan of operations which has been described have admitted that the results could scarcely be better than they are. Not only vegetables, but all the ordinary garden fruits are produced in high perfection.''

Dr. George Keith, a shrewd practical Scottish physician, who travelled much of the world, saw a great deal, and lived to be over 90 years old, had much the same experience as Dr. Vivian Poore. After describing the simple earth closet, he says—

''In Algiers, where I followed the same plan for nearly a year and a half, during one summer and two winters, the whole mass was left quite near the house, exposed to sun and rain, and I often said that one might at any time have smoothed the surface, put a table cloth over it, and eaten his dinner without being aware of any odor whatever. This is not, I acknowledge, a nice statement to make, but it certainly disposes of any possible objection that could be made on the score of health, or even of amenity. In India the dry earth system has long been in use; in the jails it has been universally adopted. Colonel Cadell, late Governor of the Andaman Islands, where are the great penal settlements of the Indian Government, tells me it is used there with perfect success, and with great advantage in the raising of vegetable foods. On one occasion he was showing Admiral Fremantle over his command, and on Viper Island he took him into a large long erection, and asked him for what purpose he would suppose it was used. The Admiral looked round, and seeing nothing but that on both sides all along the apartment the space near the wall was divided into narrow sections by wooden partitions 3ft. high, he said that perhaps some of the convicts got their food there. He was amused to hear that the apartment had been used that morning by 500 convicts as an earth closet.

''From a sanitary point of view the dry earth system is perfect, and has found to be so both in cold and in hot climates. It is surely worth something to those who adopt it to know that their own families run no risks from foul gases, and that they cannot contaminate their neighbors.''

In India the superficial burying of nightsoil is now sanctioned by official regulation. Major A. C. Williams and Major D. J. Meagher have given a full account of the method as employed at Allahabad and elsewhere. They say that wherever the method is practised correctly it is sure to give every satisfaction, and where it is not working satisfactorily it is certain that the system has not been followed. Before the system was pronounced safe on sanitary grounds, many successful experiments were made by Surgeon-Colonel Martin, who was Principal Medical Officer of the Allahabad District at that time. The depositing grounds have been inspected by most of the medical, sanitary, and other scientific authorities in India, including the Principal Medical Officer of His Majesty's forces, all of whom have expressed their unqualified approval of the system.

The authorities there find from experience that this is the best known system for both wet and dry seasons. It has been carried out at Allahabad for 14 years without any hitch, and on various descriptions of soil, including stiff clay, black cotton, and even sand. Crops can be successfully grown immediately after burying, and even in the cultivation of grass the first crop is greedily eaten by cattle. Such land should be put down to grass without ploughing. Regulation compels the sowing of a sorghum or other crop on the land.

Enough has been said to show that the earth closet system is effective in all climates, and especially serviceable in warm countries where houses are surrounded each by its open space or garden plot, or where the conditions are such that a local authority can supply earth of the proper quality in necessary quantity, and arrange for the removal and disposal of the compost. In carrying out the system, and in judging of its success or deficiencies, it is necessary to remember what the system is: "*It consists in the application, with the greatest procurable detail, of dry earth to fresh human excrement, and in the subsequent removal and use of the mixture for agricultural purposes. In so far as detailed application is not made, or the earth is not dry, or the excrement not fresh, the dry earth system is departed from.*"

THE BACTERIOLYTIC TANK SYSTEM.

In discussing the subject of the natural decomposition of dung and garbage, it was stated that the process was not a chemical, but a biological one, being due to the action of bacteria and other plants in the soil. The question naturally arises: Is the decomposition and consequent purification of sewage (*i.e.*, excreta, urine, &c., in water and not in contact with the soil) due to the same or a similar cause? Experiment has shown that it is. Not only so, but it has been found that various stages in the decomposition are associated with different kinds of bacteria, following each other in a fairly regular succession, though possibly overlapping to a considerable extent.

The proposal to utilise these bacteria in the treatment of sewage was received at first with ridicule, and was characterised as Satan casting out Satan! Nevertheless, some people who combine the practical with the scientific in their inquiries, and keep their minds open to facts for and against, persevered in their endeavors to take nature into company instead of subjecting her to banishment.

It would be interesting, but not of much practical use for our present purpose, to review the many experiments that were made in sewage purification before a simple method was discovered of employing bacteria as natural scavengers. Investigations are still in progress, and much information is being gained in various quarters with the view of determining the best methods of utilising the many varieties of bacteria, some of which do their work best when abundantly supplied with air, others when more or less completely deprived of it. Experience has shown that systems of sewage treatment can be very expensive without being correspondingly useful, and that simple methods may be successfully employed under a variety of conditions as to climate and composition of sewage. It will be best to give some selected examples of what has been done in South Australia in connection with this method of purifying sewage by bacteria, and to point out briefly the relation of these to the general theory and practice of what is commonly known as the Septic Tank System.* Be it understood, however, that the remarks apply primarily, not to towns possessing systems of sewerage on a large scale, nor to what is the best form of bacteriolytic tank system in any particular class of case, nor to the science of bacteriolytic tanks in general, but that they are meant to convey an idea of what has been done cheaply and effectively in this State in places where there is a limited quantity of sewage to be dealt with, a sufficient water supply, and where a water-closet is preferred to a dry earth closet.

In 1902 complaints were made regarding the sanitary conditions at Gawler Railway Station. The water-closets, urinals, and sinks drained into a cesspool, 10ft. in diameter and 10ft. deep, situated in a much-used yard immediately behind the station. This cesspool proved to be offensive to the residents of the station-house, and several of them suffered at various times from illnesses that were ascribed to insanitary conditions. The problem was how to put an end to the offensiveness, and to obviate the periodical nuisance and expense of having the cesspool emptied as frequently and in such a manner as the local authorities required.

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* The word ''septic'' means pertaining to the decomposition of dead organic matter, with production of an unpleasant odor, due to various forms of bacteria. It has also become specially associated with the idea of disease. For these two reasons it is inapplicable and misleading in connection with sewage purification, and should be abandoned, even if something might be said in favor of calling the first compartment a septic tank. The tanks are properly described as ''bacteriolytic,'' which means breaking up materials by the action of bacteria.

The Engineer-in-Chief, Mr. A. B. Moncrieff, consulted me on the subject. It involved such important questions of principles and practice in administration of the Health Acts and the satisfactory and economical management of the railways, that it required to be settled definitely. After visiting the locality and discussing possibilities, we determined that one of the large cesspools should be converted into a bacteriolytic tank system of two compartments, the old effluent being utilised to carry away the final products. This was done. (*See* Fig. 7.)

The tank was slightly offensive at times till a proper scum formed, which took about three months. Thereafter it was left absolutely untouched for over three years. In December, 1905, it was opened and inspected. There was no offensive smell. The scum in the first compartment was several inches thick and consisted of bluish-black, soft, homogeneous material, with a leathery-like upper surface. There was no scum on the surface of the liquid in the second compartment.

At Kapunda Railway Station a similar cesspool was converted into a bacteriolytic tank system in 1903. It also was left untouched until December, 1905, when the tank was opened and inspected. It was found to be working well, and it was quite free from offensive smell. The effluent was clear.

These two cases, it will be observed, were makeshifts. The form of the tanks and the relation of depth to surface were fixed to a certain extent by the necessities of the situation. This was not the case with an installation at the Glenelg Railway Station. There the tank was erected as a bacteriolytic tank from the beginning. It worked for years automatically and without offensiveness. In 1905 the installation of a general bacteriolytic tank system on a large scale for the town made its employment no longer necessary. The formation of a scum on the new bacteriolytic tank was unusually rapid, the old tank furnishing the material for setting the process agoing.

An example on a smaller scale, one might say on a domestic scale, may now be given. At Prospect, near Adelaide, Mr. A. W. Dunstone installed at his house a bacteriolytic tank system modified from a description published in the *Scientific American* supplement of October 17th, 1903. Two stout hardwood casks were used. (*See* Fig. 8.) One was buried on end in the ground. This received the contents from the water closet, the inlet being, as will be seen, about midway between its ends. It was ventilated at its upper end by a 1in. pipe. The second barrel was buried sidewise. The sewage passed from the first compartment into this through a short connection, which had a communication with the exterior for the purpose of inspection or removing the contents, if necessary, by pumping, in the event of the use of the apparatus being discontinued for a time. This cask had a grating of sticks which supported the filtering material and allowed the incoming fluid to circulate freely below. The filtering material consisted of broken stones, tiles, or gravel, about the size of hens' eggs, covered by rough gravel, about the size of chestnuts. The outlet from this cask led to an old well 8ft. or 10ft. deep, from which the liquid soaked into the surrounding soil. In the original American design the liquid enters a flush tank, from which it is automatically discharged into a drain. This installation was in use for several years, until it was superseded by a general sewerage system. The only attention it required was an occasional clearing of the inlet pipe from paper at the entrance into the first compartment by a rod passed through the plugged opening.

It may be well to mention other facts in connection with the use of these tanks in this State, and to set forth some of our experiences. The earliest tank about which I have been able to obtain any information in this State was installed by the late Mr. Robert Barr Smith about 18 years ago, on the recommendation and with the expert advice of Mr. William Boath, Chief Inspector of the Central Board of Health. A good deal of time and trouble was spent in endeavors to understand the structure and action of tanks from descriptions in various pamphlets by Rideal, Clowes, and others, since these dealt with principles rather than with details of structure. Before this time, Mr. Boath had discovered that a single-chambered cesspool, which had been offensive and troublesome, could be altered so as to work inoffensively and automatically as a single-chambered septic tank by introducing the inflow below the level of the surface scum.

When the first edition of this pamphlet was written in 1905 the literature on the subject was scanty and scattered. Certain principles seemed to have been established on observations and experiments; but there was little or no evidence to show whether the experience and practice of other countries, differing so much from ours in climatic and other physical and biological conditions, would prove a trustworthy guide here.

A good deal of well-digested up-to-date information, on the general subject of the bacterial treatment of sewage, was found in Dibdin's "The Purification of Sewage and Water," third edition. This proved valuable as an indication of the problems to be investigated. From the same source much information was also gained regarding the bacteriolytic tank system of treating sewage on a large scale, and the various adjuncts and auxiliaries employed in different installations. Some hints were also gleaned from various text-books on General Sanitation and Sewage Disposal, incidental papers in scientific journals and proceedings, and annual reports of Boards of Health in America.

The subject aroused a certain amount of interest in Australia. At a congress of engineers, architects, and surveyors and others interested in the building of the Federal Capital of Australia, held in May, 1901, Mr. W. Parker read a paper on "The Septic Tank System of Sewage Treatment." This dealt with general principles, and the results of large installations without any reference to any installation on a household scale. In 1902, Mr. T. Mailler Kendall read a communication before the Intercolonial Medical Congress of Australasia, at Hobart, on "The Rational Method of Sewage Disposal." In it he recounted certain experiences of treatment with the Scott-Moncrieff installation. The discussion which followed his paper dealt with such subjects as the use of the tank in small communities, hospitals, and abattoirs. The reports of the conventions of 1903 and 1904 of the National Association of Master Plumbers of Australia contain some notices of a similar sort. The proceedings of the Australian Association for the Advancement of Science are singularly destitute of reference to the septic tank system, the only communication of any note being one by Dr. Edward S. Stokes in 1907. In it certain principles are set forth, and an exhaustive account is given of several sewage installations on a large scale at North Sydney. When one considers the various contrivances and structural features that seemed to be essential, there appears to be little encouragement in those proceedings for one to introduce tanks for individual dwelling houses.

From time to time reference and descriptions appeared in the "country editions" of newspapers, sometimes with plans; but most, if not all, of these were of tanks planned on a complex system of sedimentation and filtration. The possibility or desirability of introducing tanks on an extensive scale for household use had apparently not been seriously considered. When they began to be introduced here and there, they were regarded as a luxury which only the rich could afford, or as an experiment which only the "crazy" would propose and the fool would carry out. As it happened, our initiation into the use of the tank in one or other form was gradual, and allowed ample opportunities for observation and experiment without incurring much expense or much opposition, or any costly failure by the way.

Following the issue of the first edition of this pamphlet in 1906, a general interest became manifest in this State in the bacteriolytic tank system by architects, builders, and many of the general public, who frequently asked advice regarding the possibilities of installations on various scales. On the 9th October, 1907, Mr. Boath reported that he had heard of about a dozen tanks in course of construction, the publication of the pamphlet on "Sanitation in Country Places" having given an impetus to the system. He gave a list of 35 tanks which he knew of as being in use in various parts of the State.

Many systems and plans of proposed installations were submitted by various people, and advice was given regarding these, chiefly from the point of view of simplifying their structure and of possibly bringing them into accord with what seemed to be Nature's methods, which are not usually overburdened with mechanical apparatus. It became clear that it would be advisable to observe and experiment on our own account, having regard to climate, materials, water supplies, and various other local conditions that might influence the results.

It had also become clear that the tank system was liable to abuse. Once the name of septic tank was given to any sort of installation it was frequently assumed or demanded that in virtue of the nomenclature alone it would work inoffensively and discharge a pure flow, irrespective altogether of its plan, its construction, or the materials for which it was made a common receptacle. Even when the installation was made under the supervision of a professional architect, things sometimes went wrong. One example may be selected from many, bearing on the method of administration.

In September, 1906, an architect submitted a plan for a tank for a large hotel. He was advised that one particular point in the proposed structure might vitiate the system, and he said he would alter it. In February, 1907, I inspected the tank and found that the scum had spread over the whole of the two compartments, and that the advice how to prevent such a contingency had not been followed. The defect previously pointed out was then remedied. Eight months afterwards I re-inspected the tank, and found that it was working properly. Samples of the effluent were submitted to the Government Analyst. The result is shown in a comparison with Dibdin's statistics of open and closed tanks at Leeds, given in grains per gallon, thus:—

Constituents.	Leeds Averages. Open.	Leeds Averages. Closed.	South Australian Tank.
Total solids	77.6	77.9	23.100
Suspended matter	13.1	12.8	8.800
Free ammonia	1.83	1.8	3.425
Albuminoid ammonia	0.455	0.437	0.148
Oxygen absorbed	4.18	4.82	0.315

On this I reported: "The first inference obviously to be drawn from these figures is that the liquefaction of all solids in the tank has been carried to an extent far beyond what is usual. The inference from the figures regarding ammonia (free and albuminoid) is that the purification of the resultant liquid has been carried to a point much beyond what one finds in any recorded observations." I may here note that distilled water is not to be aimed at as a standard of purity. Such a result would be doubly wasteful, a waste of money to attain it, and a product depreciated in value by such attainment. In the same report I wrote: "It is gratifying to be able to say that a large amount of interest is being taken in this method of sewage purification, or rather sewage destruction, and that scarcely a week passes without inquiries being made regarding the structure and action of the tanks by persons who are engaged in introducing them on their premises."

At this time the attitude of the Central Board of Health on the subject of installations was to watch, and assist by advice when consulted, but not to interfere, or impose any restrictions on architects or householders in connection with any proposed installation; and not to take any action except when a complaint was received of the existence of some nuisance. In such a case an order would be served specifying what was required to be done as a remedy. In the case of hotels, the Licensing Bench at the present time and as for some time past, advises or requires the introduction of these installations in a great many instances, in fact it has adopted them as part of the sanitary requirements where the conditions for a proper water supply exist; and the Central Board of Health advises in all cases referred to it, but leaves the determination to the Licensing Bench.

A description may now be given of a tank and its connections reduced to their lowest terms. Figs. 9 and 10 show a section and a plan of a tank for a new suburban railway station, drawn up by the Resident Engineer for Railways, and suitable for use at a railway station. It is connected with the closets and urinals, and discharges its effluent into a soakage pit 3ft. in diameter and 12ft. deep. These drawings represent all that is really necessary in the structure of a bacteriolytic tank. It will be observed that a tank constructed on this plan allows easily of extension, either laterally or longitudinally; and such extension to meet increased flow from additional connections is by no means uncommon.

Fig. 11 shows the sort of "block plan" that is required to be submitted under the regulations, along with the plans and sections of a tank, in order to give an idea of the tank and its connections for the purpose of approval.

For reasons that are not at first sight obvious, it was found necessary in the course of administration to require that the plans be submitted, and the requests for approval and permits made, not by the architects or contractors, but by the persons having the legal responsibility for the premises.

Closets.—No modification of the ordinary water closet is necessary in respect to structure, fittings, or position. Regarding this last matter, it is interesting to note how strongly convention holds; for many people still submit plans with the closet at a distance, sometimes at a great distance, from the house, because in their experience of country life it has always been so placed. Of course it is recognised that in the case of a closet already in existence, the question of the cost entailed by a change of position may arise and may determine its position; but even then, this amounts to very little in an installation which, once made, costs nothing for maintenance; and the convenience and comfort of an ordinary closet in or at the house may be inestimable. A copy of Regulation No. 11, quoted on page 34 below, is posted up inside of each closet.

The structure and arrangements of the cistern, closet pan, soil pipe, trap, and ventilator differ in no way from those required for an ordinary system of deep drainage. The "flush" should not amount to more than two gallons, and there should be no unnecessary discharge from the cistern.

The disposal of Bath water and Hot water will depend upon circumstances. A relatively large amount of hot water, or of soapy or greasy water, may militate against the proper action of the tank; and it may be well not to connect the bath and sinks with the tank installation unless some special precautions are taken to remove soap, fat, &c., and to cool or regulate the flow of hot water.

Position of the Tank.—This may be at any spot that is convenient. Distance from the house or closet makes no difference. Only in one case have the plans for a tank underneath a closet been submitted for approval. On account of the special circumstances and the safeguards shown in the plans, approval was given. The inlet pipe in this case discharged perpendicularly and deeply in the first compartment, so that there should be no breaking of the scum when the closet was used.

Trapping the Drain, as shown in the plan (Fig. 9), has two advantages; it allows free ventilation of the drain from the trap to the vent of the closet soil-pipe, and it prevents, as far as possible, any access of air to the liquid in the first compartment.

Relative Size of Compartments.—Sometimes the first compartment has been made the larger, sometimes the second. Provided that there is no great difference in size it does not appear to matter much which is the larger. For a considerable time, and in the majority of installations, the two have been made equal size.

Inlet.—One of the most important principles to be observed is that nothing connected with the structure or working should break or tend to break the scum that forms on the surface of the liquid in the first compartment. Hence there should be no "rush of sewage." The inlet pipe should enter below the surface of the scum. Many tanks at first had a perpendicular pipe at right angles to the entrance pipe to receive the inflow from it laterally, and direct it downwards. This, however, was useless as an "inspection" pipe if the inlet did become clogged, since it could not well be cleared unless there were a manhole just above this pipe. The form of inlet pipe shown in Fig. 9 obviates all difficulties in these respects.

Height of the Partition between the two Compartments.—The top of the partition should be about 12in. above the "outflow level" of the liquid. This is necessary because at times the scum, for some seasonal or other reasons, may attain a total thickness of a foot or a good deal more, and a large proportion of this may be above the level of the liquid in the first compartment.

Connection between the First and Second Compartments.—Several contrivances are in use for the passage of the liquid from the first to the second compartment at different levels, such as one or more bends or half-bends, or one or more simple openings in the partition. The most effective has been found to be a "syphon-bend" such as is represented in Fig. 9. One precaution is necessary. In some cases it was found that this bend failed to give passage to the liquid on account of "air-block" at its upper level. This is now obviated by boring a small hole, about a quarter of an inch in diameter, on the "shoulder" of the portion of the bend in the second compartment. The inlet pipe, the bend between the compartments, and the outlet pipe are so arranged as to give the maximum movement of flow, *i.e.*, on alternate sides of the tank.

The Outlet from the Second Compartment should be by means of a bend as shown in Fig. 9. Since the effluent of a properly working tank is inoffensive and innocuous, it may be disposed of as circumstances permit. Usually it may be conveyed in a close-jointed pipe for two or three yards, then in an open-jointed pipe, allowing irrigation of a space planted with vegetation. If this is not practicable, it may be conducted to a "soakage well." A catchpit with a porous bottom or sides is not legally, scientifically, or by any figure of speech a cesspool if it receives only the effluent of a properly working bacteriolytic tank.

Partition between the Compartments.—This is usually raised to within a couple of inches of the under surface of the cover of the tank. It should not be so low as to allow the scum from the first compartment to grow over into the second.

Ventilators.—One ventilator in a tank system is not sufficient. Two separate and independent ventilators are essential, and both may be placed on the second compartment, or one on each, provided there is an open space at the top of the partition between the compartments. It must be remembered that the function of the "ventilators" of a bacteriolytic tank is to provide a supply of oxygen for the second compartment, not to allow of the escape of foul gases or bad odors, which should not exist. One ventilator may be a sort of "inset" in the form of a small chamber, say, a "foot cube" in extent, built out from the side of one of the compartments, its top being level with the top of the tank and covered by a grating. On the other hand, it may be an ordinary ventilating tube, or a goose neck, about a foot or two in height. The other ventilator should be higher. Great height, however, is not required, 6ft. should be sufficient for all purposes. The vent pipes should be about 4in. in diameter. Their openings should be made mosquito-proof.

Manhole.—In the case of a small tank this may be placed over the centre of the tank, thus opening over the adjacent ends of both compartments. In large tanks it is preferable to have a manhole over each compartment.

Closed or Open Tanks.—In practice there seems to be a preference for a closed system. This is not based on experiment or observation, but appears to be a matter of sentiment.

Starting the Action.—Where an installation has been completed and inspected, and a permit issued for its use, the tank is filled up with water till it overflows at the outlet, and is then ready for use. A period of several weeks is usually necessary for the formation of a satisfactory scum in the first compartment; but the time may be greatly reduced by "inoculating" the liquid with materials taken from the under surface of the scum of another tank.

An idea of the general outline of a tank may be gathered from Fig. 12, which shows one in process of construction for a teahouse at the seaside. It is seen in position before the ground around it was levelled up and planted. Fig. 13 shows an inspection being made of a tank on a larger scale, situated behind the platform of a railway passenger station. The two iron covers of the man-holes, one on the top of each compartment, are seen standing erect. This tank has been in use for 16 years, and has worked perfectly.

Rarely has a tank required to be cleaned out, and in every instance the necessity for cleaning has been due to some defect of structure or management. Some tanks have been in use for 18 years, working entirely automatically, and without costing one single penny. There seems to be no limit to the life of a properly constructed tank. The essentials in the structure of an installation have all been set forth above. These are the outcome of personal observation and experiment extending over a period of about 18 years in this State, and a study of all the information that has been collected in and from other parts of the world, especially the United States and the Philippines. The things that have been examined or tested and found unnecessary have been many, such as alternating tanks; mechanical gear for feeding, resting or discharging; syphoning for periodic and intermittent discharge; an ante-chamber for sedimenting or filtering out solids; baffle plates in either or both chambers; collections of stones of various sizes in the second chamber which appeared to play an important part in the chemico-biological processes; the employment of more than two compartments, or the subdivision of either of these in any manner or to any extent whatsoever; the employment of charcoal or any similar substance; the exposure of the effluent for purification in any way; contrivances in cases of the intermittent use, as at pleasure grounds, picnic resorts, and camping grounds. These eliminations were made mostly on the ground that tanks which possessed one or more of them, and had proved offensive and incompetent, had worked properly when the adventitious appliances had been abolished.

Since regulations were passed making compulsory the submission of plans to the Central Board of Health, the following numbers have been approved in the various years since September 23rd, 1908:—

1908	2	1915	163
1909	41	1916	101
1910	50	1917	167
1911	73	1918	195
1912	95	1919	285
1913	125	1920 (to April 30th)	222
1914	167		

These number in all 1,686. It must be noted that many tanks were in use before the regulations were made in 1908.

The premises at which tanks have been installed in cities, towns, and country places throughout the State are varied as well as numerous. The list includes private houses; hotels;

boarding houses; restaurants; banks; business offices; hospitals, public and private; sanatoria; shops and stores for food and merchandise; manufacturing establishments, such as implement works, bottle works, timber mills; tramway shelters; railway stations; wheat-stacking sites; public conveniences on beaches; refreshment rooms above the sea at piers; tramway signal cabins; public pleasure grounds; camping grounds; race courses; fire stations; sheep stations; schools and colleges; convents; public halls; theatres; mines; and all sorts of places where numbers of workers are employed or where people congregate.

Many tanks having a capacity of from 1,000 to 2,000 gallons or over, and sufficient for the use of 600 persons or more, have been installed at schools, industrial works, and such like premises, all of them being built on the simple two-compartment plan here set forth. So far, we find no indications as to the limit of size within which this type is capable of working satisfactorily.

The State Department of Irrigation has recently installed 25 tanks for household and other use at one Soldiers' Settlement on the River Murray, one tank being used for two or sometimes for three closets of dwelling-houses on adjoining, though separate, blocks of land. Tanks have also been, and are being, installed in large numbers at houses built by or for returned soldiers in other parts of the State. Recently approval was asked for 76 tanks to be installed, all of one pattern, at houses to be erected in a town-planned quarter in one of the suburbs, each household to have a tank for its separate use.

An example may be given of how ingenuity and co-operation have overcome difficulties. In November, 1917, the Resident Engineer for Railways submitted for approval plans of a tank for a tramways signal cabin "to be constructed of reinforced concrete slabs similar to those erected at Hamley Bridge and Terowie". He added:—"Permission has been given by Mr. Dunn for the tank to be placed in his back yard, he being allowed to connect up the inlet pipe from the water closet at his house." When one studies the block plan of the locality (Fig. 14), and realises that the signal cabin is a structure of 9ft. by 8ft. floor space, supported overhead by pillars 14ft. high, at the corner of a street foot pavement, one admires the spirit and resourcefulness of the promoters.

For a considerable time hospitals presented difficulties, especially those in which patients suffering from infectious diseases were received. The "disinfecting" of all closets had become such an article of faith and such an ingrained habit that it was too much to expect successful results from the tanks, even when the intentions of the hospital staff were of the best. By disconnecting everything from the drainage, except closets and urinals, matters were simplified; but hospitals even now sometimes prove a difficulty.

In June, 1918, the responsible authorities of seventeen hospitals and sanatoria in various parts of the State at which installations had been in use, in some cases for many years, were asked to report on how the tanks were working. In nearly every instance the replies were completely satisfactory. In the few cases in which any difficulty had been experienced it had arisen almost invariably from some defect in structure or management which was easily remedied. It must be noted in this connection that some of these tanks had been installed before the regulations came into force.

Advice has been given when asked in cases where installations have been proposed for such places as piggeries and cream factories. It has usually been to the effect that the use of a tank for such purposes must be considered experimental at the present time, but that the experiment may be made if the proposers are willing to carry it out, and all available information has been supplied.

At the Broken Hill Central Mine, in New South Wales, the company made installations, one of a tank at the manager's house and another of a tank for seven closets for the use of 380 men, this last having a capacity of 1,887galls. This was done on the basis of a former edition of this pamphlet. These mining installations are spoken of in terms of highest appreciation and praise.

The smallest tank I recollect having inspected was one installed by a contractor for the use of his household of four persons. Each compartment measured two feet in length by a foot and a half in width and a foot and a half in depth. It worked satisfactorily for 10 years, and then was superseded by the sewerage system that was introduced for the locality.

In the fourth edition of this pamphlet, issued in 1910, I suggested that very large pipes, or complete tanks, made of reinforced concrete might prove very convenient and highly serviceable.

When these tank structures had been simplified to the present requirements, one company made tanks of a simple design in one piece, a cylinder of reinforced concrete, consisting of two compartments, and having openings for the entrance and exit pipes, ventilators, and partition bend, all ready for the reception and cementing of these adjuncts in position. These tanks and their parts are easily transported by rail to any part of the State. They are made in different sizes suitable for the use of from 6 to 100 persons. Though introduced only a few years ago, about 160 have been installed. Ten months ago the company introduced the smallest type, a tank 3½ft. in diameter, 4ft. long, suitable for six persons, and weighing 13cwts.; and since then 38 of these have been delivered.

For installations at its own stations, sidings, and sheds, the Railways Department keeps in stock the various parts of tanks, made of reinforced concrete slabs, with connections; and these parts are forwarded to any destination ready to be assembled and cemented together in position. Fig 15 shows the structural details of the manner in which the parts are fitted together when ready for use in one of these tanks. Much of the success that has characterised the evolution of the bacteriolytic tank in this State is due to the accuracy of planning and the careful attention to every detail of construction on the part of the Railways officials in every case where the installation of these tanks was recommended to them.

What happens in these tanks? After the tank has been in action for some time, if the first compartment be examined there will be found on top of the liquid a scum which goes on increasing in thickness to a certain limit, and at the bottom of the compartment a quantity of sludge. The sludge and the under surface of the scum are the abode of multitudes of bacteria, which attack the solid parts of the sewage entering the tank and dissolve them. This disintegration and subsequent solution of the sewage is supposed to be carried on principally by bacteria that act without oxygen and in darkness, conditions that exist under the scum in the first compartment which is opaque and impenetrable to air. When the sewage is thus broken down and liquefied it passes into the second compartment, where further decomposition, involving oxidation and nitrification, occurs. This is supposed to be effected by bacteria working in a plentiful supply of oxygen and light. The final product is a liquid that is inoffensive to smell and even harmless to drink. Between these kinds of bacteria (called anaerobic) that work best in total darkness and without air and those (called aerobic) that work best with an abundance of both light and air there are supposed to be many intermediate kinds; but it has not been proved that there are any sharp lines dividing bacteria into aerobic and anaerobic. In the system of tanks, one stage of decomposition overlaps another, and several species of bacteria will work simultaneously, though with varying degrees of activity. Many contrivances have been introduced to take advantage of the full working powers of the different species, such as passing the sewage over or through a succession of filters, or cultivation beds, each of which, on account of the kind of microbes growing in it, is supposed to be particularly fitted to deal with a particular condition of liquid.

Into the scientific details of these processes it is not necessary to enter. Probably if an abstract were made of all that is definitely known on the subject the statements would be considerably short of the truth. The aim in view in all variations is to purify sewage by natural means by using apparatus simple in construction and entirely automatic in action. As far as present knowledge goes, the results of experience may, for practical purposes, be summarised thus:—

1. The bacteriolytic tank should be lined with concrete and be capable of containing as nearly as possible 24 hours' sewage.

2. It is unnecessary to filter or otherwise separate the constituents of the sewage before it passes into the tank.

3. The compartments may be open or closed; if closed they should be so ventilated as to allow a constant supply of air to the second compartment.

4. The bend between the compartments and all other pipes in contact with the liquid contents should be made of earthenware or concrete. Copper, zinc, lead, and iron, unless coated with tar, are all quickly decomposed.

5. The inlets and outlets should be so arranged as to allow the maximum of distribution with the minimum of movement of the fluid, and not to interfere with the surface scum.

6. Filtration materials have been proved to be unnecessary, and sometimes they are a source of trouble.

7. The resulting liquid may be passed on to the soil by gravitation or pumping, or allowed to soak into the subsoil by means of catch wells or drains.

8. Chemicals and disinfectants tend to destroy the bacteria in the tanks and allow putrefaction to take place.

9. There is evidence to show that these tanks favor the destruction rather than the growth of the germs of typhoid fever and other diseases.

On account of difficulties in connection with the working of certain kinds of tanks, and the failures and nuisances consequent on the neglect of some principles and details, it was found necessary to make regulations dealing with the structure and use of bacteriolytic tanks. The following are the regulations in force in this State:—

1. Plans and sections of all proposed tanks, with the connections thereof, shall be submitted to the Central Board of Health for approval before the tanks are constructed.

2. No person shall use any tank until a permit authorising him to do so has been issued by the Central Board of Health, nor shall he use any tank after such permit shall have been withdrawn or cancelled.

3. As far as possible, only the service of water-closets and urinals shall be connected with any tank.

4. No person shall allow any storm water or surface drainage to enter any tank.

5. All inlet pipes to a tank shall be properly trapped and ventilated.

6. Every tank shall be constructed of brick, lined with cement, or of some impervious material approved by the Central Board of Health.

7. Every tank shall be sufficiently covered to the satisfaction of the Central Board of Health.
8. Every tank shall be provided with a trapdoor of iron or slate or other stone, so disposed as to allow of ready inspection, and the connections between the trapdoor and the tank shall be airtight.
9. The aerobic portion of every tank shall be provided with an inlet and an outlet shaft of not less than 4in. in diameter for the purpose of ventilation.
10. All bends and connections of the tank shall be made of earthenware or of wood or other material suitably tarred.
11. No person shall allow any rubbish or insoluble matter to enter any tank, or to be deposited in the pan of any water-closet or urinal connected with the tank.
12. The effluent of every tank shall be so placed as to be easily accessible for inspection.
13. The permit to use any tank may be withdrawn by the Central Board of Health in its uncontrolled discretion.
14. Penalty for breach of any of these regulations, not exceeding £20; or, in the case of a continued breach, £2 for each day that the breach is continued.

The success of the tank system in this State is largely attributable to the enforcement of these regulations.

This system has proved economical and efficient within the limits to which it has been tested. This is all that is claimed for it. It differs as much from the magnificent system installed at Baltimore (Figs. 16, 17), which I had the pleasure of examining under the guidance of Dr. William H. Welch, as a tea kettle differs from a liner's engines; yet each is good, or the best I know, for its purpose, and neither could do the work expected of the other.

Interest in this matter has not been confined to this State. I have drawn up, by request, plans and descriptions of tanks on the same principle for installations in India, Central Africa, Japan, and New Caledonia and other places in the South seas.*

It may be well to say something regarding conditions in South Australia that bear on sanitary or sewage problems. The State has an area of nearly 310,000 square miles. Concentration of population in the metropolitan area is probably more intense here than in any country in the world—52.89 per cent. of the population is massed in three cities and several towns on the Adelaide

* After this paragraph was in type I received a letter from a medical man in Manila, P.I., in which he asks for a reprint of this pamphlet. He says he constructed a tank at his own residence some years ago, following the plan set forth in a former edition which Dr. Heiser, then Director of Health for the Philippines, lent him. He adds: "It worked perfectly." He is building a new residence, and wishes advice on some points connected with its drainage system and tanks.

Plains within a radius of 10 miles from the Adelaide Town Hall, forming what might be regarded for many purposes as one large municipality with a population of over a quarter of a million.

Most of this area is well provided for by a most perfect sewerage system, which has its outlet at a "sewage farm." In the country part of the State 10 towns have between 1,000 and 3,000 of population; two have between 3,000 and 4,000; and one has 13,000. The rest of the population is spread over places of a few dozen houses or isolated dwellings. Outside of the metropolitan area no locality has a drainage system for sewage.

The water supplies for the various towns and country places are derived some from rivers or streams, some from wells or bores varying greatly in depth, some from rain water collected from roofs or in a catchment ground. There are thus many different varieties of sewage in the closets which supply the bacteriolytic tanks in different localities. Variations in the temperature of the atmosphere and soil in any given locality are often very rapid and very extensive. Besides all this, one has to take into account the general differences of temperature due to latitude and elevation. The conditions of working in the tanks vary greatly on account of the number of persons using the closets. The methods of disposing of the effluent are many; and where the effluent is used for irrigation the soils and vegetation show great differences in character.

Considering that all these matters are liable to affect the working of bacteriolytic tanks, it is somewhat surprising that it has been found possible to employ a single simple pattern, capable of any necessary modification to meet special local conditions, suitable for all the varying circumstances in the State, and working for years in such fashion that not one per cent. of these tanks has required attention for other than a trivial detail since they were installed.

In this State these tanks are now taken for granted, being regarded very much as normal appurtenances, a part of the contract, or matters of course, where new houses are erected, or where premises are extended, or where the introduction of water has made water closets possible. And the possibility or advisability of using a tank has often instigated people to the procuring of water for this purpose and for general household use in addition. A well, a stream, an underground tank for surface water or roof water, a windmill or small pumping plant or a hand pump to fill a gravitation tank or cistern on the roof or on a high platform—these are found readily when once the desire becomes felt, or when a neighbor or an acquaintance leads the way. The amount of business and pleasure travelling and friendly visiting in Australia diffuses information readily and widely regarding the necessaries and comforts and pleasures of living; and the people are receiving benefits accordingly.

DESCRIPTION OF PLATES.

ILLUSTRATIONS.

I owe the drawings for figures 7 and 8 to the kindness of Mr. A. B. Moncrieff and Mr. A. W. Dunstone respectively. To the courtesy of Mr. A. E. Welbourne (the Resident Engineer for Railways) and the skill of Mr. H. S. Blondel (the Chief Draftsman) I am indebted for the drawings of figures 9, 10, 11, 14, and 15. The artistic merit shown in the lithographic reproduction of all these is due to Mr. A. Vaughan (Government Photolithographer). The process blocks are from my own photographs.

For the speed and accuracy of work that made possible the rapid issue of this edition to meet numerous urgent requests, I would pay my sincere thanks to Mr. R. E. E. Rogers (Government Printer).

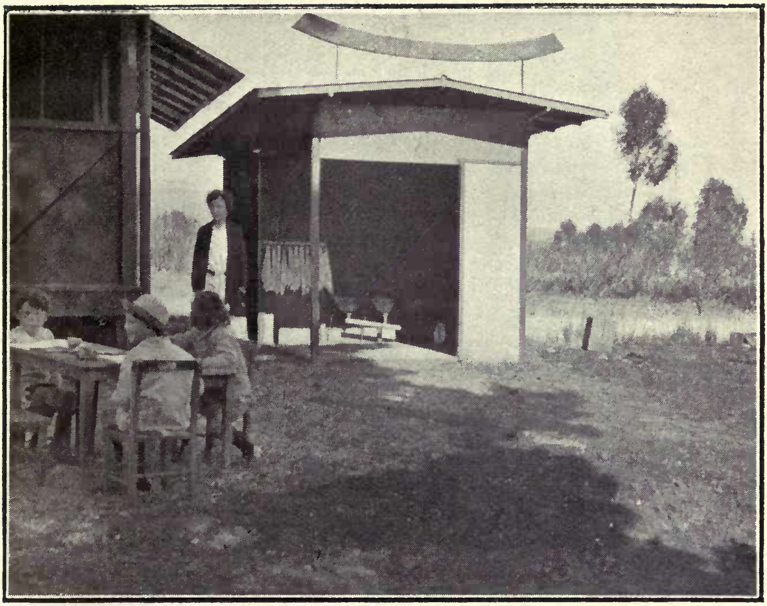


FIG. 1.

FIG. 2.

Fig. 3.

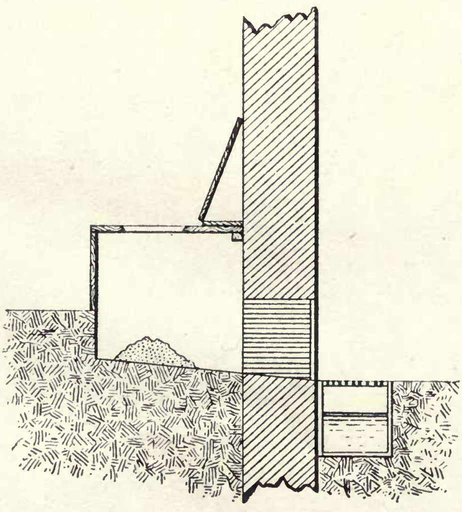
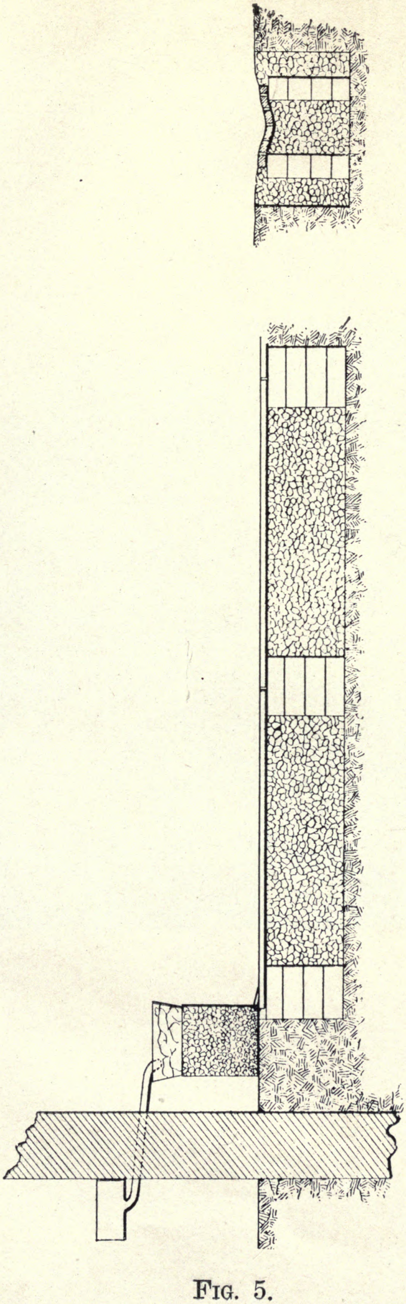


Fig. 4.



Filtration Gutter (after Poore).

FIG. 5.

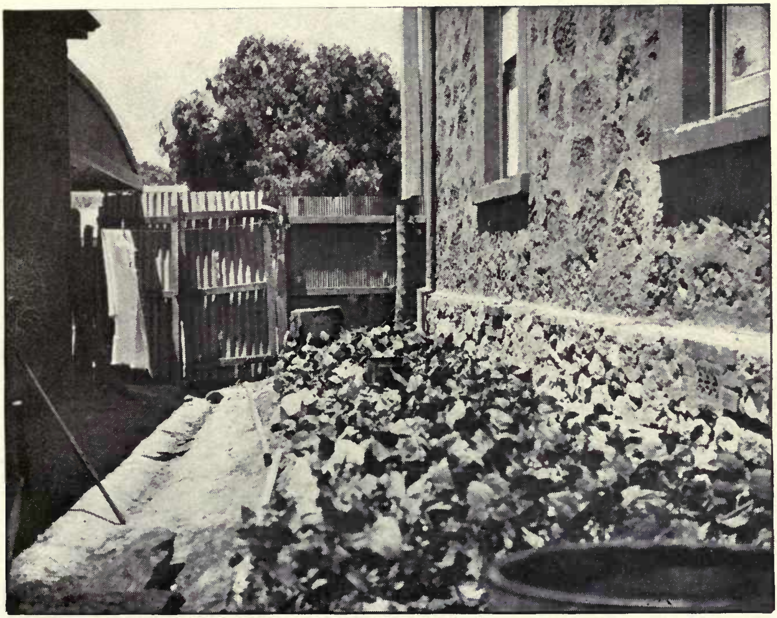


Fig. 6.

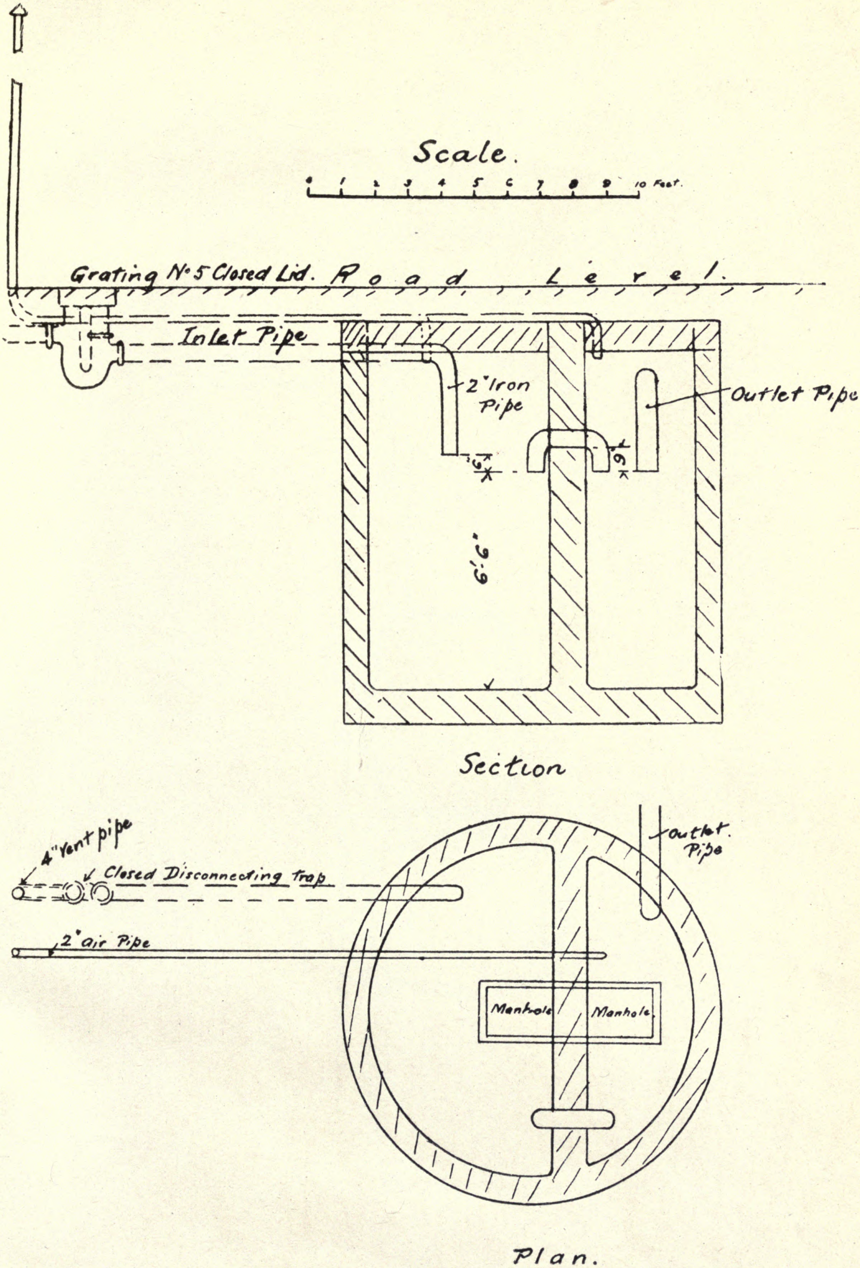

Scale.
0 1 2 3 4 5 6 7 8 9 10 Feet.
Grating Nº 5 Closed Lid. Road Level.
Inlet Pipe
2" Iron Pipe
Outlet Pipe
6"
6"
6'6"
Section
4" Vent pipe
Closed Disconnecting trap
2" air Pipe
outlet Pipe
Manhole
Manhole
Plan.

FIG. 7.

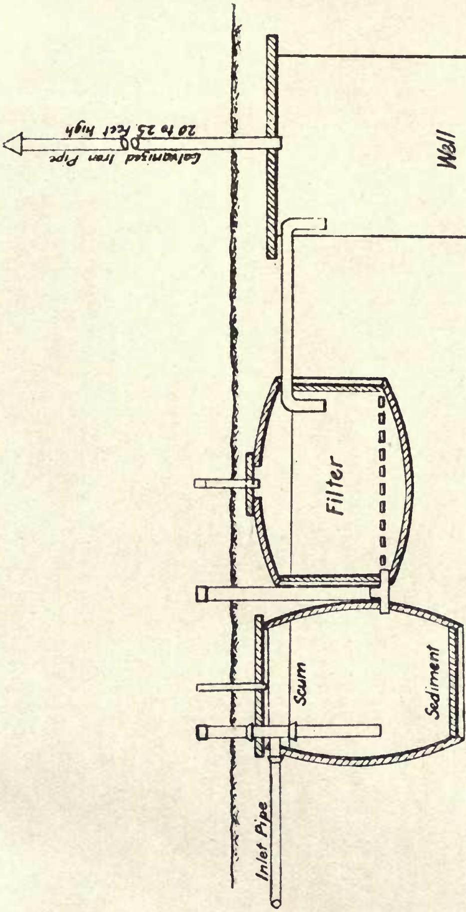
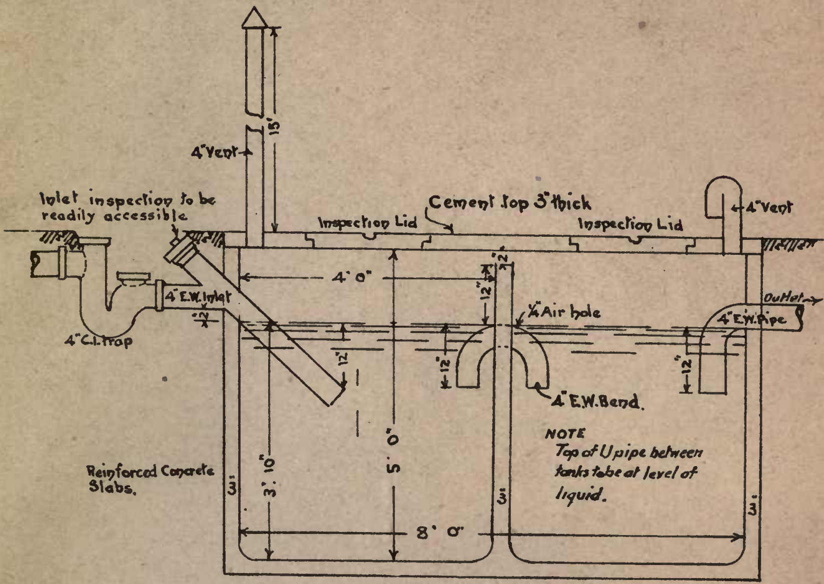
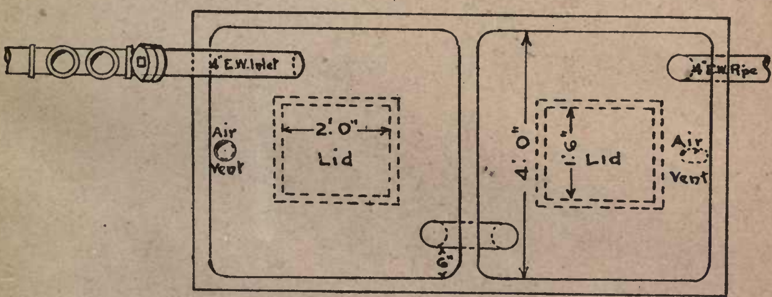

Galvanized Iron Pipe
20 to 25 feet high
Well
Filter
Scum
Sediment
Inlet Pipe

FIG. 8.



Longitudinal Section



Plan

Figs. 9 and 10

A. VAUGHAN, GOVERNMENT PHOTOLITHOGRAPHER ADELAIDE

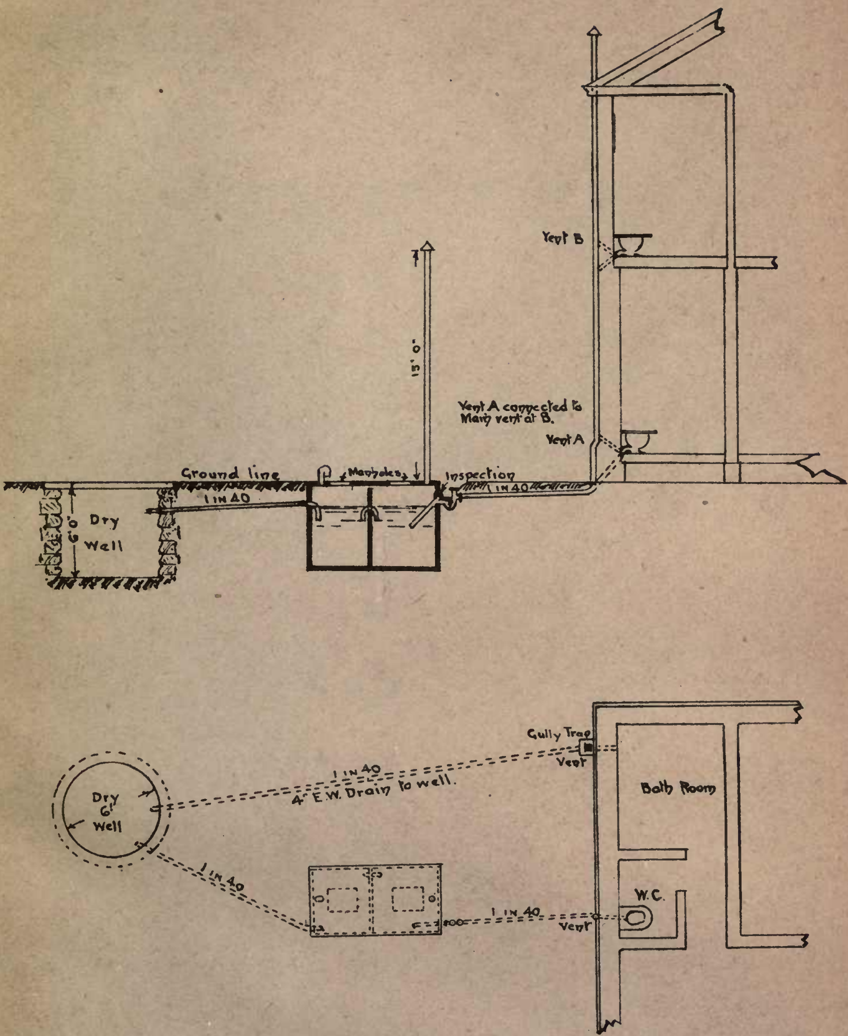


Fig. 11

A. VAUGHAN GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE

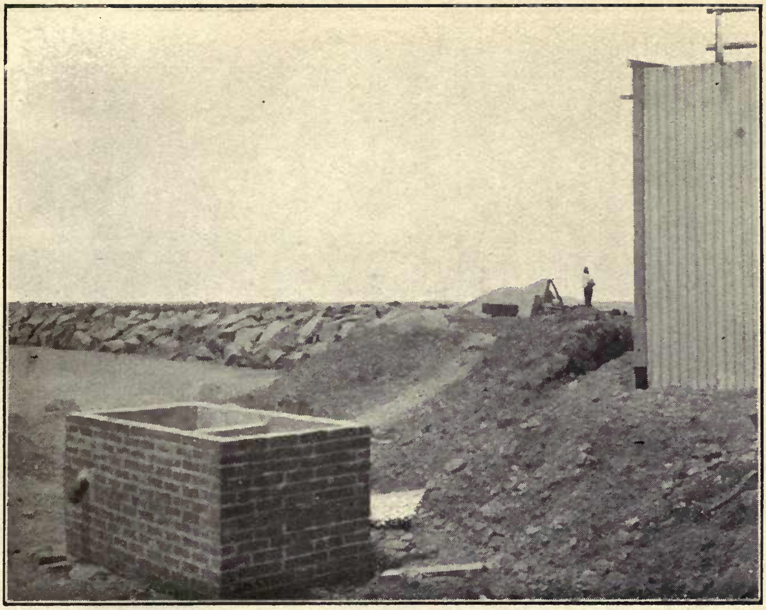


Fig. 12.

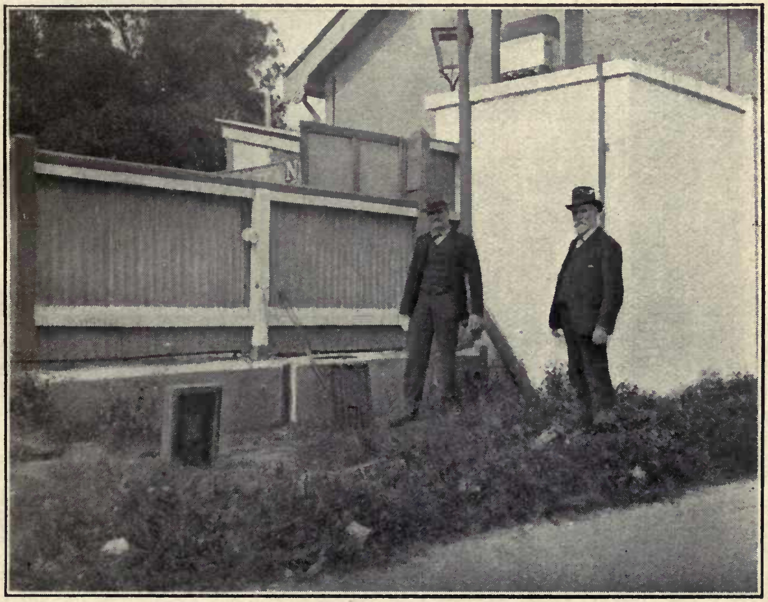
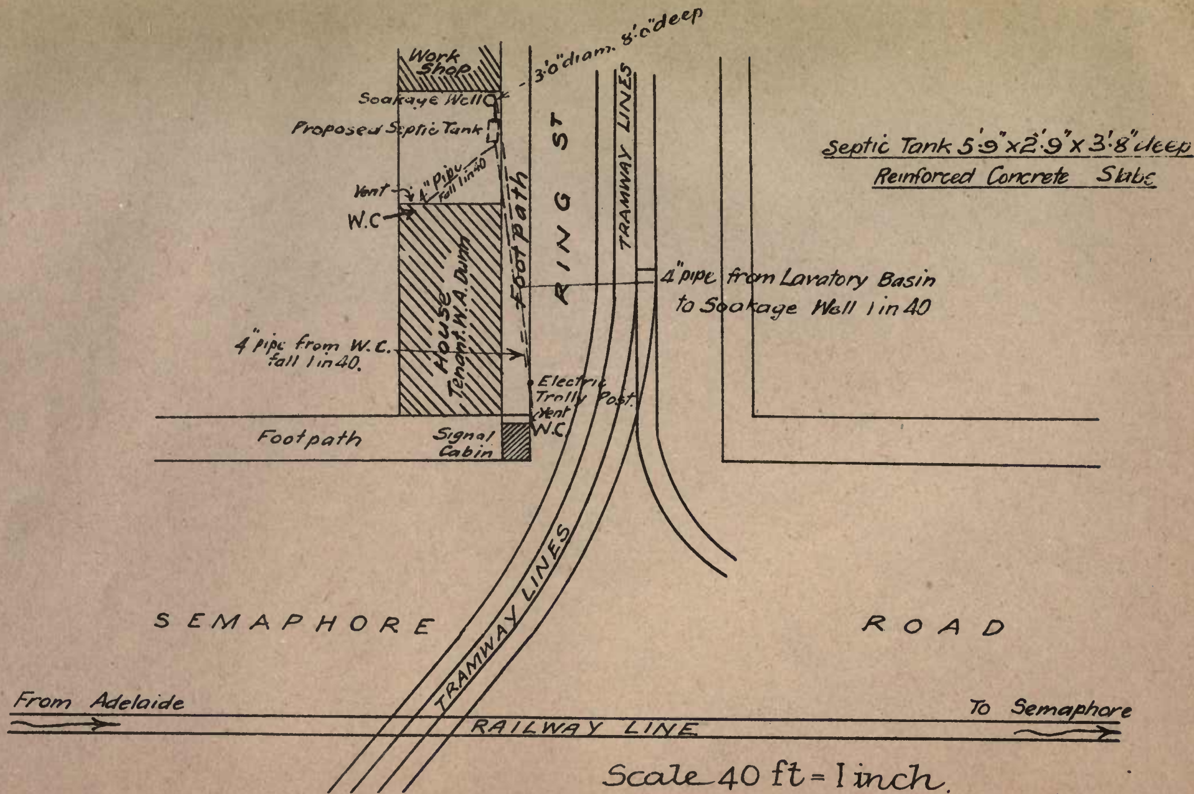


Fig. 13.



Scale 40 ft = 1 inch.

Fig. 14

A VAUGHAN, GOVERNMENT PHOTOLITHOGRAPHER, ADELAIDE

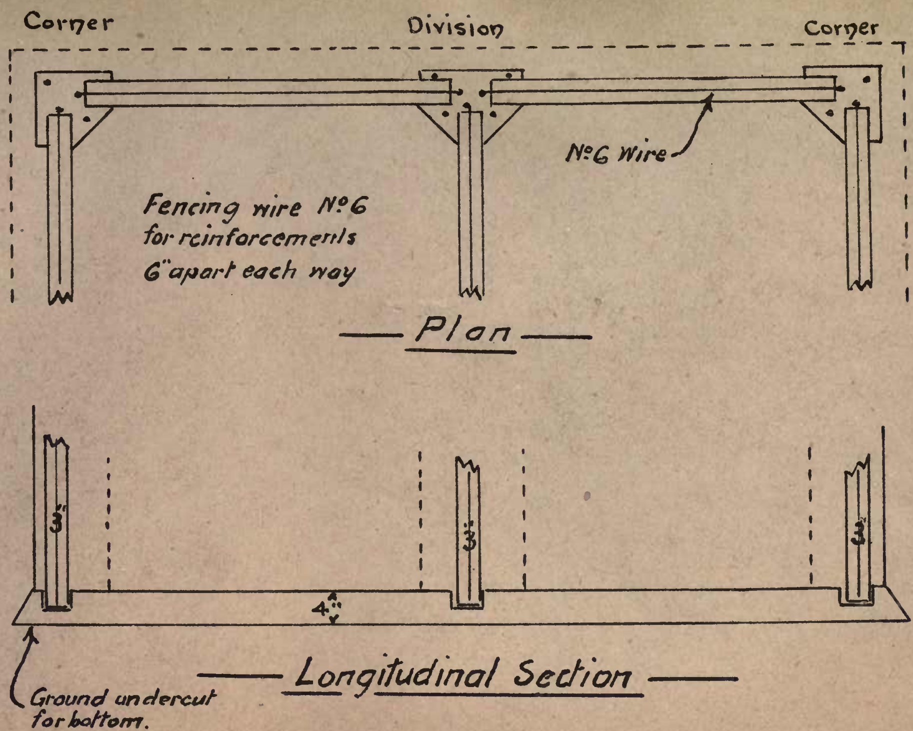


Fig. 15

A VAUGHAN GOVERNMENT PHOTOLITHOGRAPHER ADELAIDE

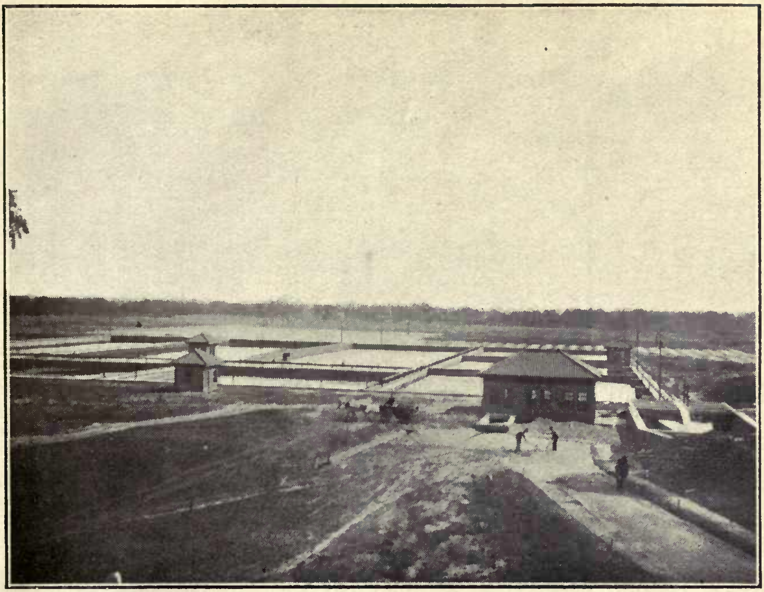


Fig. 16.

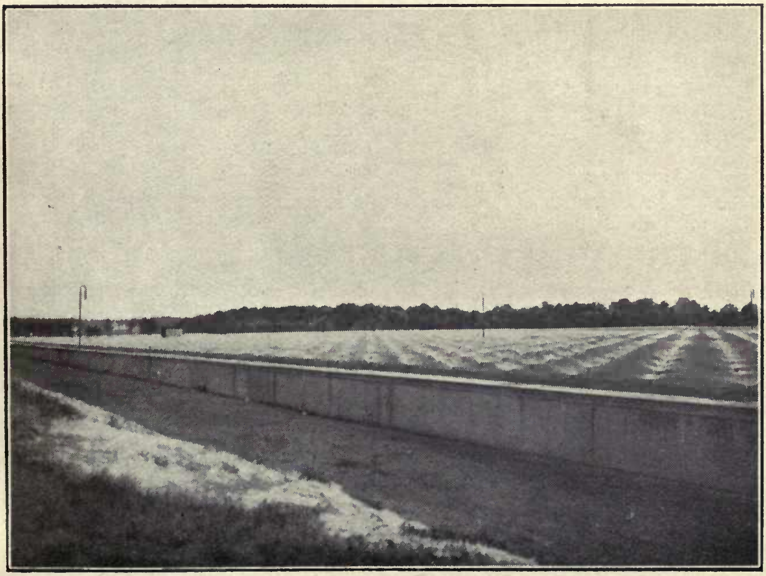


Fig. 17.